IB Chemistry | Brakke | ECA – Topic 02

T02D01 - Atomic Structure

Name KEY

Table I.

* Assume neutral

	Atomic Symbol	Protons	Atomic Number	Neutrons	Electrons	Atomic Mass
a.	Mg	12	12	12	12	24.31
b.	Mo	42	42	54	42	95.94
c.	S	16	16	16	16	32.07
d.	Ti	22	22	26	22	47.87
e.	Po	84	84	125	84	208.98

Table II.

	Atomic Symbol	Protons	Atomic Number	Neutrons	Electrons	Mass Number
a.	O	6	6	9	6	15
b.	Na	11	11	13	11	24
c.	Ti	22	22	27	22	59
d.	S	16	16	17	16	33
e.	Pt	78	78	116	78	194
f.	Ca	20	20	21	20	41

TABLE III

→ same as shorthand notation or isotopic notation.

Nuclear Symbol	Protons	Atomic Number	Neutrons	Electrons	Mass Number
$^{32}_{15}P$	15	15	17	15	32
$^{183}_{73}Ta$	73	73	110	73	183
$^{8}_{3}Li$	3	3	5	3	8
$^{163}_{66}Dy$	66	66	97	66	163
$^{74}_{34}Se$	34	34	40	34	74

Table IV

Isotope Name	*Nuclear Symbol*	*Protons*	*Electrons*	*Neutrons*	*Mass Number*
Iron-57	$^{57}_{26}Fe$	26	26	31	57
Carbon-14	$^{14}_{6}C$	6	6	8	14
Arsenic-77	$^{77}_{33}As$	33	33	44	77

Isotopic Abundance:

1. A natural sample of gallium consists of two isotopes with masses of 68.95 amu and 70.95 amu and with abundances of 60.16% and 39.84%, respectively. What is the average atomic mass of gallium?

^{69}Ga ^{71}Ga

(0.6016 × 68.95amu) + (0.3984 × 70.95amu) =

41.4803 + 28.2665 = 69.75 = $A_{r\,Gallium}$

2. Antimony, one of the elements knows to the ancient alchemists, has two stable isotopes: ^{121}Sb (mass, 120.90) and ^{123}Sb (mass, 122.90). Calculate the percent abundance of the two isotopes. [HINT: In order to do this problem you have to use the "weighted average" atomic mass from the periodic table.]

^{121}Sb ^{123}Sb

(x · 120.90) + (1 - x · 122.90) = 121.76amu ← from periodic table.

120.90x + 122.90 − 122.90x = 121.76 amu

−2x = −1.14

x = 0.57

x = 0.57 ⇒ ^{121}Sb = 57.00%

1 − x = 0.43 ⇒ ^{123}Sb = 43%

3. The element rhenium (Re) has two naturally occurring isotopes, ^{185}Re and ^{187}Re with an average atomic mass of 186.207 amu. Rhenium is 62.60% ^{187}Re and the atomic mass of of ^{187}Re is 186.956 amu. Calculate the mass of ^{185}Re.

^{187}Re ^{185}Re

(0.6260 × 186.956)(1 - .6260 × ^{185}Re) = 186.207 amu = $A_{r\,Rhenium}$

(117.0) + (0.374 × ^{185}Re) = 186.207 amu

0.374 × ^{185}Re = 69.207

^{185}Re = 185.045amu

4. Naturally occurring europium consists of two isotopes with masses 150.9199 and 152.9212. Calculate the isotopic abundance of each isotope knowing that the average atomic mass from the periodic table is 151.964.

^{151}Eu ^{153}Eu

(x · 150.9199) + ((1-x) · 152.9212) = 151.964 = $A_{r\,Europium}$

150.9199x + 152.9212 − 152.9212x = 151.964

−2.0013x = −0.9572

x = 0.478

x = 0.478 ⇒ ^{151}Eu = 47.8%

1 − x = 0.522 ⇒ ^{153}Eu = 52.2%

5. Naturally occurring boron consists of two isotopes boron-10 and boron-11 with masses of 10.013 amu and 11.009 amu respectively. Boron-10 has an abundance of 19.99%. Calculate the average atomic mass as would be found on the periodic table.

$(10.013 \times 0.1999)(11.009 \times 0.8001) = 10.81\ amu = A_{r\,Boron}$

6. Chromium (atomic mass of 51.9961 amu) has 4 isotopes. Their masses are 49.9461 amu, 51.9405 amu, 52.9407 amu and 53.9389 amu. The last two isotopes have abundances of 9.50% and 2.35%. Estimate the other two abundances.

$9.50 + 2.35 = 11.85 \rightarrow 88.15$

$51.9961\ amu = A_{r\,chromium} = (49.9461 \cdot x) + (51.9405 \cdot (0.8815 - x)) + (52.9407 \cdot 0.0950) + (53.9389 \cdot 0.0235)$

$51.9961 = 49.9461x + 45.786 - 51.9405x + 5.029 + 1.268$

$-0.0869 = -1.994x$

$x = 0.04358$

$x = 0.0435$ → $^{50}Cr = 4.358\%$

$0.8815 - x = 0.83792$

$^{52}Cr = 83.79\%$

7. Gallium has two naturally occurring isotopes, ^{69}Ga has an isotopic abundance of 60.11% and a mass of 68.9256 amu). Calculate the mass of the other isotope ^{71}Ga from this information. Use the periodic table to find the weighted average of these two naturally occurring isotopes.

$A_{r\,Gallium} = 69.732\ amu = (68.9256 \times 0.6011) + (x \cdot (1 - 0.6011))$

$69.732 = 41.4312 + 0.3989x$

$28.3008 = 0.3989x$

$x = 70.9471 = {}^{71}Ga$

Describe the development of the atomic theory (briefly but using diagrams is possible).